Target localization using a novel electromagnetic high precision positioning system in patients with localized prostate cancer

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Introduction

Image-guided radiotherapy (IGRT) techniques are being increasingly implemented. An important issue in IGRT is intrafraction and interfraction organ motion. The Micropos 4DRT system is being developed to provide accurate, precise, objective, and continuous target localization throughout the course of clinical radiotherapy. This study presents the first *in vivo* use of the system.

Aim of Study

To evaluate *in vivo* the target localization accuracy of a novel electromagnetic positioning technique and to assess its real-time tracking ability.

Materials & Methods

An active positioning marker was temporarily inserted in the prostatic urethra (Fig.1A) of 13 patients scheduled to recieve external radiotherapy for localized prostate cancer. A recieving sensor plate (antennae system) was placed at a known position in the treatment tabletop (Fig.1B). After 3 initial patients, system calibrations were performed. 10 additional patients were then included in a descriptive feasibility study that compared radiographic transponder location to radiotransponder location. With three registered positions per patient, a total of thirty positions were available for comparison. For every position a frontal and side 2D kilovoltage radiograph was obtained using a commercial virtual simulation system (Ximatron radiotherapy simulator, Varian). Each pair of 2D radiographs allows calculation of a 3D position for comparison with the Micropos system position data. Points of reference (radiopaque markers) were located in the recieving plate to allow comparison of radiographic localisation data with Micropos data. Synchronous registration of positioning data from the Micropos system was made at each of the radiographic localizations.

Table 1 *The three-dimensional shift in mm between the Micropos 4DRT positioning system and the corresponding X-ray images. Absolute (A) and relative (R) mean 3D (±SD) differences given.*

Patient	A1	A2	A3	R1-2	R1-3
SU – 01	2.8	0.8	0.9	2.1	1.5
SU – 02	2.8	3.6	4.8	2.7	1.6
SU – 03	2.1	2.4	2.5	1.6	0.2
SU – 04	2.5	2.3	2.8	0.8	2.3
SU – 05	5.6	1.5	1.6	4.6	1.9
SU – 06	1.8	2.2	2.2	0.9	1.0
SU – 07	3.6	4.4	3.0	0.9	2.1
SU – 08	0.8	0.9	1.9	1.5	1.1
SU – 09	3.0	2.7	3.5	0.9	1.2
SU – 10	4.9	2.8	4.3	3.5	1.6
All		2.7 ± 1.2 mm		1.7 ± 1.0 mm	

Results

All temporary transponder insertion and localization procedures were successful and without any patient complications. Comparison of the patient localization on the basis of the transponder location as per the Micropos 4DRT system with the radiographic transponder localization showed an average (±SD) absolute and relative 3D difference of 2.7 ± 1.2 and 1.7±1.0 mm respectively (Table 1). The absolute measurement was made by comparing the 3 dimensional position from the Micropos positioning system to the X-ray images relative to the reference markers in the receiving sensor plate. For each patient the implant was placed in three different positions (A1-3). The relative measurement was made by comparing the movement of the implant from the middle position to the end positions from the system to the X-ray images. Two comparable movements were thus obtained for each patient (R1-2/R2-3). System real-time tracking demonstrating organ motion was also successfully performed (data not shown).

Figure 1A *Illustration of transponder positioning in the prostatic urethra by use of a dilation catheter.*

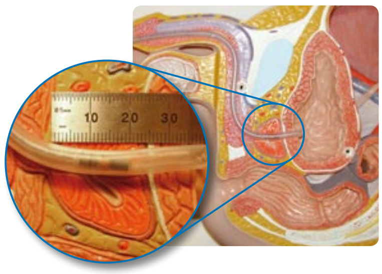
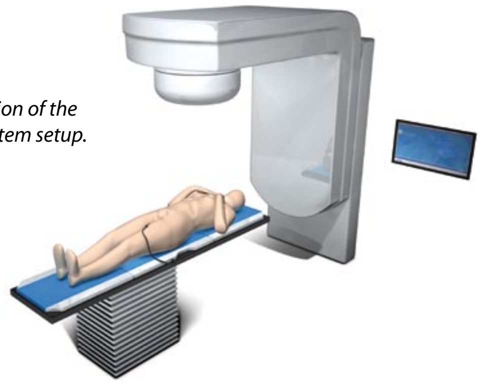


Figure 1B *Illustration of the Micropos 4DRT system setup.*



Conclusions

- *In vivo* use of the Micropos 4DRT system allows for high-precision target localization (<3mm 3D difference)
- This novel non-ionizing technique appears well suited for real-time organ motion tracking